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The Effects of Mirroring in a Playful Virtual Environment: A Comparative Study with Children and Adults Having Impairments

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Abstract. This study explored the effects of a projected self-image in a game situation created for people with different impairments and ages, to question life quality and social cognition. A simple video capture game utilizing the Microsoft Kinect enabling embodied interaction was created. Test sessions consisting of two test conditions, a mirrored self-image condition and a silhouette condition, were conducted with repeated measurement and an interval of one week between each condition. The participants were from four special needs daycare centers and selected by caregivers. They consisted of 20 children (10 male, 10 female) and nine adults (three male, six female), all with various impairments. Video recordings were analyzed with a qualitative case study approach, and a follow up semi-structured "in-situ" interview with the caregivers was held to support the interpretations. Overall findings indicate that the system has a variety of possibilities and the participants used it in their own way e.g. for rough-and-tumble play, creative expression, and as a medium for cooperation. However there was no visible difference between the mirrored condition and the silhouette condition.

1 Introduction

Previously, according to Lanier [1], there was an overlap between the research in Virtual Reality (VR) and the research into tools for supporting disabilities. There were no distinctions between these two areas of research because their goals are almost the same; to use technology on the terms of the people and not the other way around. This is still a trend. It is underlined that the exploration of mirroring in virtual systems is a promising development toward future methods of treatment [2, 3, 4]. In line with this strategy, the way of working with children and adults having special needs has evolved from inclusion [5] and accessibility [6], to a dynamic strategy that includes "quality of life" (QoL) aspects and transfers to everyday life. The basic idea in this body of work is to use engaging play to create an expressive and stimulating environment to supplement traditional intervention approaches to generate this quality of life approach for people with impairments.

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This paper reports on a study where the effects of a projected self-image in a game situation were investigated to question life quality and social cognition. A QoL framework in line with Flanagan [7] was utilized focusing on the use of engaging play to create an expressive environment to supplement traditional intervention approaches. This approach contrasts an "Activities in Daily Living" (ADL) approach focusing on training of everyday tasks [2, 3].

The core of this research is self-recognition and mirroring relating to the concept of self-presence where a link is created between the person and a virtual self. Ulrike [8] defines self-presence as when a person identifies him- or herself with an avatar and the connection transcends mere control; the avatar becomes an extension of the person. In this way, self-presence represents a feeling of agency where the person becomes the avatar [9]. Mirroring is defined as the personal experience when looking in a mirror or as defined in this paper, when seeing a projection of the self in a digital game designed for the motion sensing input device; the Microsoft Kinect. Mirroring influences self-perception such that "empathic behavior cannot emerge until the child has a concept of self and is capable of taking the role of another or being influenced by someone 'like me'" [10, p. 235].

2 Methods

In order to investigate the effects of mirroring and self-recognition, a game with two different visual outputs was designed through a 'Rapid Applications Development' (RAD) life cycle process that involved the participants in the design process. The test was conducted through repeated sessions over a period of five weeks. Each participant took part in two sessions with at least one week between the sessions.

The setup of the test was different in each of the four special needs daycare centers. All setups consisted of the Microsoft Kinect placed so that it was able to record the participant in an area where the participant, dependent on ability, could either lie or sit while watching the projection of the game e.g. on a screen or a nearby wall. If the color of the area was not suited for chroma keying it was covered with a piece of green or blue cloth. During the session the participant played the game with either a caregiver, project group member, or another participant. Each session was video recorded.

A case study approach [11] was applied as the sample from the special needs daycare centers contained children and adults with different impairments and different challenges. Furthermore there was little control over the events in the test. The video recordings of the participants were detailed and full of amassed thick data for analysis on the individual participants, which made the data ideal to analyze as a case study. Generalizations can be difficult as each case study was a detailed description of each individual's experience of the system based on his or her specific impairment.

Based on a set of sample requirements, six out of 29 participants were selected as individual case study subjects after viewing the video material from an Interaction Analysis approach [12]. These requirements included that the participants had to have been exposed to both conditions with more than seven days between exposures, they should experience the conditions without influence from other participants, the footage of their faces had to be available, and the case study analysis had to be based on both children and adults. Footage from the rest of the participants was used to support or discard tendencies seen in the case studies.

2.1 The Joint Application Development

During the development process in the RAD life cycle, caregivers from the different special needs daycare centers were involved. They defined each of the participants' profiles via their weaknesses, likes and dislikes and clarified the participants' expectations to the process and the system. In addition the caregivers participated and contributed with reflections regarding the system. These steps also contributed to the evaluation and review phases. Based on the input from 'Joint Application Development' meetings as a part of a participatory design approach, a series of basic design goals were developed.

The study included two separate test sessions; one session with a mirrored projection of the participant and the other session with a silhouette projection. The sessions were video captured and a comparative analysis between the mirroring and silhouette imaging outputs was conducted. Following the test sessions, semi-structured in-situ interviews were held with the caregivers. These included a form of co-editing of the video material in order to question the interpretations and to evaluate the findings in line with Buur and Ylirisku [13].

2.2 Participants

A total of 29 participants took part in the experiment: 20 children (10 male, 10 female) and nine adults (three male, six female). The participants came from four different special care special needs daycare centers and were selected by their caregivers and the criterion was whether the children or adults would be interested in playing the game.

2.3 The Game

During project initiation, a series of goals and rules were decided to guide the design process. The system should be adaptive and mobile in order to function within a range of different environments to address variance in user needs [14].

Fig. 1. A screenshot from the game

As the game was intended for a wide audience of children and adults with different impairments, users with limited motion range and physical disabilities had to be taken into consideration. This was addressed by implementing an adjustable activity zone to achieve the 'Zone of Optimized Motivation' (ZOOM) [15], supporting people with impairments to have playful experiences. The open-ended goal of the game was to activate three differently colored boxes that then colored the virtual setting around the participant, enabling the participants to also use the game as medium for creative expression.

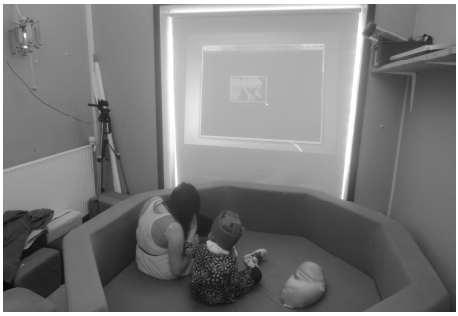

Fig. 2. The setup consisted of a laptop, which was running the game, a projector, a Kinect and the green cloth covering the play area

3 Results

3.1 Case Studies

In follow-up interviews, information about the participants' diagnosis and profile were received from the caregivers. This information was outlined for the six participants in the case studies as follows:

Participant 1 is a five-years-of-age female with no diagnosed impairment, but considered mildly disabled mentally. She needs long time to adapt and prefers playing alone.

Participant 2 is a five-years-of-age female with no clear diagnosis. Her development is stunted and not corresponding to age. She needs a clear structure and gets distracted easily, and if so, she reacts with distress, crying and sometimes aggressive behavior.

Participant 3 is a four-years-of-age male with very impulsive behavior. His actions are controlled by his impulses, and this often inhibits him playing with others. He mainly uses simple sounds as his utterances.

Participant 4 is a four-years-of-age male with cerebral palsy. He does not have any verbal language and have difficulties communicating. He likes to observe other children playing but finds crowds uncomfortable.

Participant 5 is a four-years-of-age male, diagnosed with AMC (Arthrogryposis Multiplex Congenita). He is wheelchair bound and unable to use his legs and his arms

can only be used to a certain degree. His cognitive abilities are those of a traditionally developed child.

Participant 6 is a young adult male having a physical age approximating 20 years but a mental condition of a child around three-to-four-years-of-age. He easily gets distracted. He is an active young man who enjoys visual entertainment. He lives at a special needs daycare center.

3.2 Area of Analysis

During the analysis of the children and adults interacting with the game, it was evident that two topics repeatedly occurred as the main tendencies. The terms for the two themes, which emerged after processing the video material with data triangulation and Interaction Analysis [12], were created by the project group. The focus for the case study analysis was: Self-Recognition and Shared Experience.

4 Discussion

4.1 Self-recognition

This study has analyzed self-recognition, differentiating between direct indication and indirect indication. Within these two structures, inspired by Brooks-Gunn and Lewis' six behavioral categories [10], actions that indicate self-recognition have been analyzed.

Indirect Self-recognition
Indirect self-recognition is defined as performing actions that indirectly indicate mirroring. This includes actions such as performing active gestures while observing the screen and performing intentional gestures within the context of the game.

Participant 1, 3 and 6 showed a combination of indirect and direct self-recognition. Participant 1 and 3 were both highly active under the test, standing up and walking around. In comparison, Participant 6 is similarly physically able to be active but chose to lie on his back throughout the test. The tendency observed from the participants from the children-aimed special needs daycare centers, was that they (Participants 1-5) were as active as they were physically able to be; the children who could stand preferred to stand. The occurrence of indirect self-recognition seems constant over the two tests, with the exception of participant 5 who more than doubles his indirect expressions in his second test; silhouette projection. Participants 4 and 5 exclusively showed signs of indirect self-recognitions. They are both profoundly physically disabled and their motoric skills severely limit their ability to express themselves explicitly.

Direct Self-recognition
Direct Self-Recognition is defined as performing actions, which clearly shows mirroring such as pointing at oneself, or rearranging one's clothing or hair as a reaction to the captured self-image.

Interestingly, participants 1 and 6 both showed no signs of direct self-recognition in their silhouette test in comparison to their mirrored test where they had many of such expressions. This might indicate that the condition showing the mirrored embodiment is easier to understand than the silhouette projection. This is in line with the work of Brooks-Gunn and Lewis [10].

Rearranging one's clothing or hair was observed in the cases of participants 1 and 6 but both only in the mirror version. While this is a clear sign of mirroring, it is not a sign of a higher understanding other than being able to identify oneself. The fact that it only happened in the mirror projection should not be interpreted as the participants having a better experience of this condition as it can be attributed to the representation of them being more visually detailed and interested.

Fig. 3. Participants showing signs of direct self-recognition

4.2 Shared Experience

The importance of social interaction, hereunder the role of the facilitator and the role of peer-learning, as a determinant of learning and development is emphasized by Vygotsky [16]. This has been an inspiration for this work to generalize on the subject and analyze for shared experiences in the sessions. Shared Experience is considered as the times where a child or adult playing the game interacts with others while playing. This includes showing and acting together to complete a task. In the case of participant 5 and participant 4, participant 5 helps participant 4 to reach the boxes, by leading his hand towards the active areas in the game. They both seem to react with enjoyment to the peer experience. Participant 1 used the caregiver as an extended tool in the game; identifying the caregiver in the game, and trying to control how and what the caregiver does. Participant 3 is at one point playing together with several other children while interacting with the game. There is no caregiver guiding this play and even when they play rough it is directed towards the game and not the other players. This indicates that throughout the game, he was able to play with others without guidance from caregivers. How the participants interacted with the game was deemed dependent on their impairment and their ability to focus, but there is indication towards the game enabling social interaction.

4.3 The Role of the Facilitator

The caregivers' influence on the test is twofold: Firstly they dictate and guide the participants in the play session, and in some cases function as the primary mediator between the participant and the game. The caregiver's personal engagement and ability to facilitate the participants during the play session, dictates the interaction. Secondly by assisting in interpreting the video data. The caregivers' personal opinion of the game is a potential influence to their feedback when interpreting data.

An example on the former is when a female child is interacting with caregivers while being in the game in one of the sessions. The facilitator and the child create a play where the child rolls her whole body across the floor of the play area to activate the sounds from the game. After a while the caregiver leaves the session and another newly arrived caregiver enters. The child tries to continue the movements, but fails to do so because the new caregiver, unaware of the child's self-invented play, wants the child to interact with the game in a different way. Here the influence of the caregivers is obvious as the child, at first is a bit frustrated but then ends up changing behavior with the second caregiver and creates a new play accordingly. The degree of learning and development is highly influenced by the caregiver: The first caregiver and the child in this case quickly find a good way of interacting with the game, which results in the child moving and laughing. As the child is physically limited, movement is a part of her daily training. The second caregiver does not seem to obtain the same level of interaction with the child and the game, and the child never reaches the same level of enjoyment and movements as when being in the session with the first caregiver.

Fig. 4. On the left an example of the facilitator guiding the experience. On the right an example of a shared experience between the participants.

In the case of participant 4 and participant 5, where they interact with each other in a session, the caregiver and participant 4 is alone in the start of the session. The caregiver helps the participant to move his arms as he is unable to do so alone. Participant 5 observes their session and is suggested to participate, which he accepts. When he enters, participant 4 reacts with joy (noises indicating laugh), participant 5 helps participant 4 move his arms and this increases the indications of joy from participant 4. The caregiver encouraged peer-experience by inviting the other participant, and the caregiver's role shifted from being the one helping participant 4 to facilitating peer-experience and hence the reactions from participant 4 changed.

Participant 5, though motorically limited, is guiding the interactions and it is believed that this can influence his feeling of empowerment, as he is able to help others.

4.4 Mirroring

The effects of mirroring have been difficult to determine, but it has been observed that the reactions were increased direct self-recognition when using the game with a mirrored self-image. According to the caregivers from the special needs daycare centers, the participants seemed more engaged when they could see their mirrored self-image within the game. The participants often expressed joy when identifying themselves as a part of the game, and in the case of e.g. participant 6, the caregivers replied that there was a noticeable change in the attention span when he was able to see himself in the game. In some cases, especially when the participants were severely disabled both physically and mentally, there was no change in their reactions while interacting with the game with mirroring compared to their interactions with the game with silhouette.

4.5 The Adjustable Activity Zone

The adjustable activity zone proved sufficiently adaptable to a wide range of physical impairment, e.g. a paraplegic wheelchair user could use his head to participate and get a playful experience. For future studies the adjustable activity zone could be moved during the sessions to challenge the participants' range of motion. This could also help to distinguish intentional activation of colored boxes from coincidental interaction when analyzing results.

5 Conclusion

This study focused on the effects of a projected self-image in a game situation. A case study was carried out in order to investigate if there was a difference between a mirrored self-image condition and a silhouette condition. The results showed two emerging themes namely that firstly, in the mirroring condition, the participants showed tendencies toward increased enjoyment in the virtual environment, as the self-recognition often evoked joy, laughter and pointing behavior toward the projection. Secondly, that the sessions were highly affected by the mood of the participants, their mental model of the room and their degree of impairment, how much they enjoyed the system (or if they enjoyed it at all) and their ability to keep their concentration during the tests. However, even for the participants with problems concentrating, they were able to concentrate at some point during the tests. It was concluded that the social aspects with regards to both mirroring and enjoyment, seem to have an impact on the experience. Children used the system as a tool for enabling play with others, and children and adults working together with either caregivers or other participants to activate the system, but this is not representative for all cases.

The physical position of the setup is very important, as the participants seem to have a need for identifying the setup before entering the room in order to be comfortable with it, and the possibility of repeatedly being in the system.

It can be concluded that the system has a variety of possibilities, and the participants are using the system in different ways, which opens up the possibility for further development.

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